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ORIGINAL

UNITED STATES—REPUBLIC OF CHINA

Cooperative Science Program

JOINT STATUS REPORT

October 1, 1976
through
September 30, 1977

NATIONAL SCIENCE COUNCIL, R.O.C.
NATIONAL SCIENCE FOUNDATION, U.S.A.

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This report was jointly prepared by the National Science Foundation in Washington, D.C. and the National Science Council in Taipei, Taiwan, the Executive Agencies respectively for the United States—Republic of China Cooperative Science Program.

Further information on the program may be obtained by writing to: the Division of International Programs, National Science Foundation, 1800 G Street, N.W., Washington, D.C. 20550, or the Division of International Programs, National Science Council, 2 Canton Street, Taipei 107, Taiwan.

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INTRODUCTION

The United States—Republic of China Cooperative Science Program was established on January 23, 1969, by an exchange of notes between the Minister of Foreign Affairs for the Republic of China and the Ambassador of the United States to the Republic of China. These notes constituted an agreement that remained in force for six years and was renewed for an additional five years on January 23, 1975. This status report reviews the Program's activities from October 1, 1976 through September 30, 1977.

The objectives of the bilateral program are: (1) to increase the contacts and cooperation among scientists, engineers, scholars and institutions of research and higher learning of the two countries; (2) to provide more frequent opportunities for the exchange of informations, ideas, skills, and techniques; (3) to attack problems of mutual interest; and (4) to utilize special facilities available in both countries. All recognized branches of science and technology are included within the scope of cooperation under the Program.

The Program supports the following types of activities: (1) the exchange of scientists, including both short-term and long-term visits; (2) cooperative research; (3) joint seminars and advisory meetings.

The 1976 annual Joint Staff Meeting of the Executive Agencies was held in Taipei, Taiwan, Republic of China on October 26-28.

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EXCHANGE OF SCIENTISTS

Short-Term Visiting Scientists

The objective of the short-term visiting scientist activity is program development, especially for cooperative research. During the period under review, a total of fourteen U.S. scientists were approved; twelve completed their visits in FY 1977, and the other two were scheduled to carry out their visits after October 1, 1977. One Chinese scientist visits the United States under this category.

The visitors' names, affiliations, host institutions, activities, and the duration of visit are listed below.

U.S. to R.O.C.

1. Henry O.A. Meyer and Yuch-Ning Shieh
   Department of Geosciences,Purdue University
   Host Institution: Mining Research and Service Organization
   Stable isotope and mineral chemistry of Cenozoic igneous rocks and associated ore bodies in Taiwan.
   December 3-13, 1976
2. Charles E. Birkeland and Richard H. Randall
   Marine Laboratory, University of Guam
   Host Institution: Institute of Oceanography, National Taiwan University
   The effects of fish grazing on the balance in competition between algae and juvenile corals.
   January 3-15, 1977
3. Ronald J. Fuchs and John M. Street
   Department of Geography, University of Hawaii at Manoa
   Host Institution: National Taiwan University
   Land use change and environmental degradation in Taiwan in the post-war period.
   December 29, 1976 - January 15, 1977
4. Thomas T.H. Wan
   Department of Sociology, University of Maryland, Baltimore County
   Host Institution: National Taiwan University Medical School
   Comparing Socio-medical systems in Appalachia and Taiwan.
   August 1-29, 1977
5. Michael P. Wnuk
   Material Research Laboratory, South Dakota State University
   Host Institution: National Central University
   Quasi-static and dynamic fracture problems in viscoelastic media
   March 27 - April 17, 1977

6. Shigeji Fujita
Department of Physics and Astronomy, State University of New York at Buffalo
Host Instituion: National Taiwan University
Cyclotron resonance lineshape and mobility of a two-dimensional electon-impurity system
August 17-26, 1977
7. S.H. Chan
Energetics Department, University of Wisconsin, Milwaukee
Host Institution: Institute of Nuclear Energy Research
Thermal-hydraulic analysis of nuclear reactor safety
June 11 - July 10, 1977
8. Cho C. Tsen
Department of Grain Science and Industry, Kansas State University
Host Institution: National Taiwan University
Effects of processing conditions on the nutritive value of regular and protein-fortified cereal based foods
August 23 - September 3, 1977
9. Hsin-Yi Lin
Department of Geology, University of Washington
Host Institution: National Taiwan University
Radiolaria and diatoms in the Kuroshio Current
August 29 - September 12, 1977
10. Richard A. Meyer
Nuclear Chemistry Division, Lawrence Livermore Laboratory
Host Institution: Institute of Nuclear Energy Research
Rapid radio chemical separations and spectroscopy measurements of short-lived radioactive species
October 1-8, 1977
11. V.R. Srinivasan
Department of Microbiology, Louisiana State University
Host Institute: National Chunghsing University
Microbial enzymes and solid-state fermentation
November 6-8, and November 27 - December 4, 1977

R.O.C. to U.S.

1. Cheng-Ching Chen
Department of Chemical Engineering, National Taiwan University
Host Institution: West Virginia University
Applying coal gasification process to the gasification of cellulosic wastes
August 28 - September 5, 1977

Long-Term Visiting Scientists

This activity enables scientists from the United States and from the Republic of China to visit the counterpart country for the purpose of conducting collaborative research. The duration of visits generally ranges from six to twelve months. Six U.S. scientists were in Taiwan during the reporting period, and four Chinese scientists were in the United States.

The names and institutions of the visiting scientists and hosts, their research topics, and the duration of visits are listed below.

U.S. to R.O.C.

1. Paul Vander Meer
   California State University, Fresno
   Host: C.H. Chao
   National Chengchi University
   A socioeconomic study leading to increasing the size of farms in Taiwan
   June-September 1976 and June-September 1977
2. T.Y. Lin
   University of South Carolina, Aiken
   Host: C.K. Shen
   National Taiwan University
   Problems in stable homotopy theory and cohomology theory of transformation groups
   September 1976 - September 1977
3. Kang-Jey Ho
   University of Alabama, Birmingham
   Host: Z.S. Chen
   National Taiwan University
   Biliary lipid composition and excretion and its relationship to cholelithiasis
   September 1976 - September 1977
4. Donald B. Zobel
   Oregon State University
   Host: Valiant C. Liu
   Taiwan Forest Research Institute
   Water Relation of *Chamaecyparis* in Taiwan
   September 1976 - June 1977
5. Janis Antonovics
   Duke University
   Host: Hong-Pang Wu
   Academia Sinica
   Genotype environmental interactions in the yield of the second crop of rice in Taiwan
   August 1977 - January 1978
6. Chan-Nan Chang
   University of Massachusetts
   Host: Men-Chin Hu
   Academia Sinica
   Cohomology theory of transformation groups
   August 1977 - July 1978

R.O.C. to U.S.

1. Yuan Shan
   National Tsinghua University
   Host: Robert T. Poe
   University of California, Riverside
   Laser-atomic and molecular physics—application of many body theory to solid-state and chemical lasers
   March 1977 - Febraury 1978
2. Chien-tse Chu
   National Taiwan University
   Host: John Hook

National Cancer Institute
Antibodies against foamy viruses in nasopharyngeal carcinoma patients
July-December 1977

3. Y.H. Fan
   National Taiwan University
   Host: David Simoneff and John Estes
   University of California, Santa Barbara
   Remote sensing technique and its applications in land use studies
   July 1977 - February 1978

4. Wen-chang Chang
   National Taiwan University
   Host: Choh-Hao Li
   University of California, San Francisco
   Fish pituitary hormones
   July 1977 - April 1978

COOPERATIVE RESEARCH

Thirty-six cooperative research projects, including fifteen begun during the reporting period, were active in FY 1977. Listed below are the titles of the research, the principal investigators of both countries and their institutions, the duration of the projects, the objectives and, where applicable, significant achievements.

1. Evaluation and recovery of detrital heavy minerals
   U.S.: D.J. Cook, University of Alaska
   R.O.C.: V.C. Lee, Mining Research and Service Organization
   H.S. Liu, National Chengkung University
   Duration: June 1973-May 1977
   Objective: To Determine the occurrence, distribution and methods of recovery of detrital minerals in alluvial deposts of Alaska and Taiwan.
   Achievement: Magnetite, ilmenitem zircon, and monazite in alluvial deposits along the east coast of Taiwan were systematically investigated. Magnetite has been identified as a heavy mineral of economic importance in Taiwan.

2. Biochemical studies of the toughening of harvested asparagus
   U.S.: S.F. Yang, University of California, Davis
   R.O.C.: J.C. Su, National Taiwan University
   Duration: December 1974-November 1976
   Objective: To assess the possible involvement of ethylene in the toughening process, to determine the ethylene production rate of various parts of harvested asparagus, to determine the ethylene production rate of various parts of harvested asparagus, and to examine the effect of ethylene on the activity of various enzyme systems.
   Achievements: Preliminary results indicate that ethylene stimulates lignin formation. White asparagus produces more ethylene than green asparagus during growth, and therefore, it is tougher than green asparagus. Ethylene changes the quality but not the quantity of lignins in the seedling and alters the enzyme distribution pattern in green asparagus. These findings are applicable in the production of asparagus.

3. Petrologic, structural and tectonic investigation of the paired metamorphic belts and ophiolites of Taiwan
   U.S.: W.G. Ernst, University of California, Los Angeles
   R.O.C.: Y. Wang, National Taiwan University
   Duration: January 1975 - December 1976
   Objective: To investigate the structure, lithology, metamorphism and geochronology of the Tailuku and Yuli belts as well as the coast range ophiolite suite.
   Achievement: A preliminary model of the structural and tectonic evolution of Taiwan was constructed. It has allowed recognition of erosional intervals and subsequent recrystallizations in the history of the mountain-building process. Documentation has been obtained of both pre-Eocine and post-Eocine metamorphism, of hiatus periods

in rock deposition and of the environment of Mesozoic metamorphism; careful mapping of a few key areas in the central mountains of Taiwan has been completed.

4. Atomic-field bremsstrahlung and related processes
U.S.: R.H. Pratt, University of Pittsburgh
R.O.C.: H.K. Tseng, National Central University
Duration: April 1975 - March 1977
Objective: To make theoretical studies of radiative processes, particularly a systematic study of the electron-bremsstrahlung spectrum and angular distributions as a function of atomic-number Z and incident-electron kinetic energy.
Achievement: The investigators concentrated on two problems: tabulating the neutral bremsstrahlung spectrum and measuring angular distributions of photoelectrons. Bremsstrahlung calculations are currently at the limit of available computer capabilities; a method is being designed to extend these calculations into the million electron volt (MeV) range, which, if successful will represent a significant breakthrough. Such calculations are of interest in the fields of public health (measuring radiation hazards) and energy (as a diagnostic tool in fusion research). In the second area, preliminary reports of the photoelectron distribution studies, which represent the first serious attempts to understand the consequences of relativity and retardation on distribution, have been presented at several national and international conferences.

5. Sludge stabilization by high-dosage chlorination
U.S.: T.H. Feng, University of Massachusetts
R.O.C. W.F. Wang, National Taiwan University
Duration: June 1975 - May 1977
Objective: To investigate sludge stabilization by means of high-dosage chlorination and the impact of resulting compounds on the environment.
Achievement: The process of high-dosage chlorination in the treatment of night soil in Taiwan has been found to be as effective as its application to the treatment of septic tank pumpings in the United States. However, the major concern has been the effects of the formed chlorocompounds on the aquatic environment. In this regard, toxity bioassays, using different species of fish as test animals, are either underway or being planned. The replacement of chlorine with ozone was considered, but the process was found to be impractical, mainly due to the difficulties involved in applying ozone at the very high dosages necessary, a few thousand times higher than those used in water purification. In addition, uncertainty remains regarding the environmental impact of the degradation products of high-dosage ozonation.

6. Plant cell, tissue and organ cultures of economic plants
U.S.: T. Murashige, University of California, Riverside
R.O.C.: P.J. Wang, Academia Sinica
S.S. Ma, National Taiwan University
Duration: July 1975-June 1977
Objective: To identify the parameters that require systematic assessment when developing plant cell, tissue and organ cultures for clonal propagation.

Achievement: The study has resulted in 1) rapid, *in vitro* clonal propagation of many plants in large quantities, including ferns and house plants, tropical foliage plants, shade trees, farm crops, many garden vegetables, fruits and flowers, timber crops *(Cryptomeria)*, potatoes, cabbages, spices and flowers; 2) Production of virus-free plants, including citrus trees, potatoes, garlic and ginger; and 3) use of *in vitro* cultures to transport germ plasm.

7. Wind-induced water-surface set-up and drift currents
U.S.: J. Wu, University of Delaware
R.O.C.: F.L.W. Tang, National Chengkung University
Duration: August 1975 - July 1977
Objective: To make measurements both in the field and in the laboratory of water motion and surface tilt under various wind velocities, to scale the results and to relate them to the wind velocity and the wind fetch.
Achievement: Data were collected and analyzed in two laboratories in Taiwan, as well as in the field, to determine the relationship between surface drift currents and wind velocity and between surface set-up and wind velocity. A numerical model was constructed based upon these raw data and the results of the analyses. In addition results of measurements in tanks of different sizes were compared to determine the scaling laws for field applications. The model on surface drift current may be used as a diagnostic tool for predicting the movements of water pollutants, especially oil slicks and thermal pollutin from nuclear power plants.

8. Distribution and cycling of some pollutant heavy metals in the estuary of the Ta-Tu River, Taichung area, Taiwan
U.S.: D.C. Burrell, University of Alaska
R.O.C.: T.S. Hung, National Taiwan University
Duration: December 1975 - November 1978
Objective: To provide some baseline data on various physical, chemical, biological and geological factors on the coastal environment and estuary of the Ta-Tu river and study heavy metal contamination in waters, sediments and marine organisms.

9. Biology of *Fusarium* disease
U.S. W.C. Snyder & S.N. Smith, University of California, Berkeley
R.O.C.: T. C. Wang, Taiwan Sugar Research Institute
S.K. Sun, National Chunghsing University
Duration: February 1976 - January 1977
Objective: To study the epidemiology and biological control of crop plants caused by various species of *Fusarium*.
Achievement: Preliminary results on the biological control of Panama disease of banana from both pot and field trials were promisng. Flooding and alkalization of field soil reduced the disease development. Further disease suppression was achieved by applying certain biological factors. Introduction of wilt-suppressive soil, application of antagonistic bacteria, plant residues and some chemical compounds into field soil before flooding resulted in better control. These biological control measures were more effective on heavier soils the lighter ones.

10. A Chinese language research computer system
    U.S.: Y.H. Chu, University of Maryland
    R.O.C.: T.Y. Chiang, National Taiwan University
    Duration: April 1976 - March 1978
    Objective: To design and implement a Chinese language research computer system that directly accepts and executes a high-level Chinese programming language.

11. Developments on Kirkwood's dielectric theory to the study of molecular interactions in liquid solutions
    U.S.: E. Grunwald, Brandeis University
    R.O.C.: K.C. Pan, Tamkang College of Arts and Sciences
    Duration: April 1976 - April 1978
    Objective: To elucidate hydrogen-bonding interactions by applying dielectric constants for solutions of hydrogen-bonding solutes in hydroxylic solvents to recent developments in Kirkwoods dielectric theory.

12. Philippine Sea seismic survey
    U.S.: G.G. Shor, Jr., University of California, San Diego
    R.O.C.: T. Lu, National Taiwan University
    Duration: May 1976 - May 1977
    Objective: To undertake a geological study of the crustal structure in the Philippine Sea between Guam and Taiwan.

13. Pharmacokinetic studies on procainamide and its metabolites
    U.S.: L. Z. Benet, University of California, San Francisco
    R.O.C.: S.Y. Chow, National Yangming Medical College
    Duration: May 1976 - May 1978
    Objective: By using the simple urine test methods of Edius in phenotyping isomiazid inactivators, to determine whether the Chinese population is predominantly fast or slow acetylators; and to develop an overall scheme for dosage administration of procainamide in cardiac patients depending upon their acetylator phenotype, renal and hepatic functions.
    Achievement: Urine tests for phenotyping isoniazid inactivators have been made, and results are promising. More than 65% of the patients are fast acetylators, about 25% are slow acetylators, and 10% are intermediate. These results are comparable to those reported for other Asian countries.,

14. Chalcone and chalcone-like hetrocyclic compounds
    U.S.: E.J. Lien, University of Southern California
    R.O.C.: K.K. Hsu, National Taiwan University
    Duration: June 1976 - June 1978
    Objective: To synthesize four series of chalcone and chalcone-like heterocyclic compounds, to investigate their antimicrobial activities, and to study the relationships between biological activities and their chemical structures.
    Achievement: 73 compounds of chalcone and chalcone-like derivatives have been synthesized; 9 compounds have antimicrobial activities (MIC 1r/m1) for *Candida albicans, Trichophyton rubrum, Aspergillus, Staphylococcus aureaus, Pseudomonas aeruginosa* and *Escherichia coli.*

15. Crack propagation in structural members under mixed mode loading
    U.S.: G.C. Sih, Lehigh University
    R.O.C.: C.S. Yeh, National Taiwan University

Duration: June 1976 - June 1978
Objective: To carry out experimental and theoretical studies on the fracture toughness and fatigue strength of the engineering materials produced and utilized in both the United States and the Republic of China; to investigate the crack growth rate of materials under cyclic loading.

16. Development of textured vegetable protein and other food products from soybean
U.S.: C.K. Rha, Massachusetts Institute of Technology
R.O.C.: C.F. Lee, Food Industry Research and Development Institute
Duration: June 1976 - June 1978
Objective: To develop high protein foods from soybean and to explore new processes for traditional Chinese soy products preparation in order to increase the production rate and yield, and also to improve the quality of the products.
Achievement: A new process to produce topi (tofupi, soybean protein-lipid film, or yuba) by employing a drum dryer equipped with a second coating applicator was developed. This new process is capable of producing topi continuously and automatically. The physical and chemical properties of the drum-dried topi have been examined and compared with the traditional product. These properties include thickness, texture profile, tensile characteristics and chemical and amino acids composition.

17. Radio frequency plasma heating via mode conversion
U.S.: T.W. Tang, University of Massachusetts
R.O.C.: K.Y. Fu, National Taiwan University
Duration: June 1976 - June 1977
Objective: To investigate the theoretical and experimental problems of mode conversion between the extraordinary mode (microwave) and the electrostatic Bernstein mode (wave) at the lower hybird resonance.

18. Removal of trace metals from municipal sludges
U.S.: C.P. Huang, University of Delaware
R.O.C.: J.F. Kao, National Chengkung University
Duration: September 1976 - August 1978
Objective: To measure and evaluate the metal chelation capacity of ethylenediamine-tetraacetate, EDTA, in the removal of trace metals from municipal sludges; to test the effect of sulfide oxidation to metal chelation reaction; and to examine the combined metal chelation-ultrafiltration process for protein recovery.

19. Observation of upper atmospheric disturbances caused by typhoons and other tropical storms
U.S.: R.J. Hung, University of Alabama, Huntsville
R.O.C.: J.J. Chen, National Central University
Duration: September 1976 - August 1978
Objective: To investigate the coupling between the lower and upper atmosphere during periods of typhoons and other tropical storms, by employing ionospheric doppler frequency fluctuations recorded, available from ionospheric doppler sounder array.

20. Genetic modification of plant cells by protoplast fusion
U.S.: Indra K. Vasil, University of Florida
R.O.C.: M.C. Liu, Taiwan Sugar Research Institute
Duration: September 1976 - August 1978

Objective: To explore methods of somatic hybridization between the casava and sugarcane crops through protoplast culture.

21. Neural regulations of ingestive behavior
U.S.: Matthew J. Wayner, Syracuse University
R.O.C.: T.H. Yin, National Defense Medical Center
Duration: September 1976 - August 1978
Objective: To investigate the organization of the ingestive mechanism in the hypothalamus in relation to sensory afferents from peripheral receptive sites and to small aggregates of neurons in the hypothalamus.

22. Quantitative analysis of biological control of *Rhizoctonia* diseases
U.S.: Ralph Baker, Colorado State University
R.O.C.: T. Tschen, National Chunghsing University, and C.C. Tu, Taiwan Agricultural Research Institute
Duration: March 1977 - March 1978
Objective: To compare the effect of plant tissues on the control of different anastomosing groups of *R. Solani;* to clarify the behavior of *R. solani* in soils heavily infested with other pathogenic or saprohytic fungi.

23. Development of a practical, multipurpose urban air pollution diffusion model
U.S.: David C. Chou, University of Iowa
R.O.C.: C.Y. Hsieh, National Taiwan University
Duration: March 1977 - November 1977
Objective: To investigate and to develop a practical, computerized, multi-purpose, atmospheric dispersion model; to study the inert carbon monoxide, other photo-reactive, and automobile-generated pollutants by employing the method of matched asymptotic expansion.

24. Positron annihilation in gases in the vicinity of the critical point (separate grants were made to U.S. investigators by NSF)
U.S.: S. H. Chen, Massachusetts Institute of Technology, and
S.J. Tao, New England Institute
R.O.C.: P.K. Tseng, National Taiwan University
Duration: May 1977 - December 1978
Objective: To carry out a series of experimental, as well as theoretical, studies of positron annihilation in dense gases, to investigate the annihilation life times and angular correlation of annihilation gamma rays in xenon, carbon dioxide and argon in the vicinity of the critical point.

25. Laboratory and numerical modeling of the effects on typhoons when encountering the mountains of Taiwan Island
U.S.: H.P. Pao, Catholic University of America
R.O.C.: C.. Wang, Academia Sinica
Duration: October 1976 - October 1977
Objective: To construct a numerical model which will properly incorporate phenomena in the form of an initial-value problem of the full equations of motion of a stratified atmosphere in the presence of a two-dimensional mountain ridge.

26. Attenuation, intensity and characteristics of strong ground motions and seismic response of embedded structures
U.S.: J. Penzien, University of California, Berkeley
R.O.C.: C.H. Yeh, National Taiwan University

Duration: March 1977 - March 1979
Objective: To carry out research in the areas of attenuation, expected maximum ground acceleration and ground motion characteristics; to investigate the soil-structure interaction of embedded structures.

27. Earthquake resistant design and strengthening of shear walls in concrete buildings
U.S.: Le-Wu Lu, Lehigh University
R.O.C.: Y.B. Tsai, Academia Sinica
Duration: To study the effectiveness of concrete walls with new design arrangements of reinforcing steels and wire mesh, under earthquake loadings.

28. Mycological study—survey of fungal parasitism in Gramineae (Poaceae), Cyperaceae, Legumunosae (Fabaceae) and Rosaceae in Taiwan
U.S.: T.M. Koyama, The New York Botanical Garden
R.O.C.: Z.C. Chen, National Taiwan University
Duration: May 1977 - April 1979
Objective: To investigate the fungal parasitism in four major families, Gramineae, Cyperaceae, Leguminosae and Rosaceae in Taiwan with special reference to its systematic significance in the classification of both fungi and host plants.

29. NMR and spectrophotometric studies on hemocyanin in Taiwan Snails
U.S.: Norman C. Li, Duquesne University
R.O.C.: S.M. Wang, National Tsinghua University
Duration: August 1977 - Febraury 1978
Objective: To investigate the proton NMR spectra of imidazole in the presence of hemocyanin obtained from Taiwan snails. Absorption spectrophotometric studies using imidazole as a proble will be carried out to eliminate the active-site of hemocyanin.

30. A study on the mechanics of earthquakes in Taiwan
U.S.: F.T. Wu, State University of New York at Binghamton
R.O.C.: Y.B. Tsai, Academia Sinica
Duration: December 1976 - November 1978
Objective: To carry out tilt studies surrounding the microearthquake source area and C^{14} dating of raised marine terraces on the eastern side of the coastal range; to continue recording and analyzing microearthquake data in the Tsengwen area.

31. Growth kinetics of bacteria on silicate-ligno-cellulose and effects on macromolecular composition of cells
U.S.: D.W. Thayer, Texas Tech University
R.O.C.: K.C. Lin, Food Industrial Research and Development Institute
Duration: October 1976 - September 1978
Objective: To determine (1) the nutritional composition of rice hulls, (2) the suitability of rice hulls as an energy and carbon source for the growth of bacteria, and (3) the effect of mild pretreatments on the ability of bacteria to use the rice hulls as a growth substrate.

32. Study on grafted starch polymers
U.S.: Mitchel Shen, University of California, Berkeley
R.O.C.: CC. Lin, National Taiwan University
Duration: January 1977 - January 1979
Objective: To synthesize a new grafted starch with more applications than raw starches such as potato, tapioca, corn and wheat.

33. Seismicity and focal mechanism studies of the region between Taiwan and Luzon
    U.S.: Carl D. Bowin, Woods Hole Oceanographic Institute
    R.O.C.: M. T. Lin, Academia Sinica
    Duration: August 1977 - July 1979
    Objective: To study seismicity and focal mechanism in order to improve the understanding of present tectonic processes of the area between Taiwan and Luzon based on geophysical data and geological features.

34. A comparison of benthic community structure and species morphology between Taiwan and Guam in relation to temperature, upwelling, and fish grazing
    U.S.: R. H. Randall and C. Biekeland, University of Guam
    J. E. Randall, University of Hawaii
    R. O.C.: Y.M. Tseng, National Taiwan University
    Duration: September 1977 - August 1979
    Objective: To test the hypotehsis that some of the differences between the benthic communities of Taiwan and the other region of the Indo-West Pacific are due to the effects of water temperature, nutrient upwelling and the activities of grazing fishes and other large animals.

35. Induced stresses and fatigue response of bridge elements
    U.S.: Jackson C. S. Yang and Conrad P. Heins, University of Maryland
    R.O.C.: J. P. Tang, National Central University and H. C. Lee, National Taiwan University
    Duration: December 1976 - December 1977
    Objective: To develop the Randomdec method of structural analysis into a system for monitoring damage to steel bridges, and to develop design load spectra by identifying the effects of wind, earthquakes, and the use of vehicles on structural elements of bridges in the two countries.

36. Mesoscale dynamics in upwelling off east coast of Taiwan
    U.S.: Ya Hsueh, Florida State University
    R.O.C.: C. Y. Lee, National Taiwan University
    Duration: April 1975 - March 1977
    Objective: To investigate the physical dynamics of upwelling off the southeastern coast of Taiwan. Direct current measurements and hydrographic surveys are being conducted from the Chinese research vessel, R/V Chiu Lien, in a time-series study. Studies include bathymetry, stratification of the waters, circulation, density field, and the local climatology.

SEMINARS AND ADVISORY MEETINGS

Seminars

Seminars are convened to promote the exchange of information and ideas among specialists and to identify a selected number of topics appropriate for consideration as future cooperative research projects. Specific subject areas for seminars are designated by NSF and NSC.

Six seminars were approved immediately prior to or during FY 1977, three of which were held during the reporting period with 40 Americans and 86 Chinese scientists attending. The remianing three are scheduled to take place after October 1, 1977.

The titles, locations, dates, coordinators and approximate number of attendees are listed below:

1. Solid State Physics
   Sessions: Taipei, Taiwan; April 7-13, 1977
   U.S.: Robert Maurer, University of Illinois, and 7 others
   R.O.C.: H.H. Chen, National Tsinghua University, and 63 others
2. Polymer Science
   Sessions: Saint Louis, Missouri; May 23-26, 1977
   U.S.: John Kardos, Washington University, and 15 others
   R.O.C.: Teh Hu, National Tsinghua University, and 8 others
3. Neurophysiology
   Sessions: La Jolla, California; July 6-9, 1977
   U.S.: Floyd Bloom, the Salk Institute, and 15 others
   R.O.C.: C.Y. Tsai, National Defense Medical Center and 12 others

The three seminar scheduled to be held October 1977 - September 1978 are:

1. Fermentation
   U.S.: Arthur E. Humphrey, University of Pennsylvania
   R.O.C.: Shih-Yu Huang, National Taiwan University
   Planning Session: November 13-18, 1977, New York City
   Seminar Dates: May 30 - June 1, 1978, Philadelphia
2. Marine Algae
   U.S.: Maxwell S. Doty, University of Hawaii,
   Roy T. Tsuda, University of Guam
   R.O.C.: Young-Ming Chiang, National Taiwan University, Taipei
   Planning Session: June 8-9, 1977, Guam &
   August 15-23, 1977, Honolulu
   Seminar Dates: June 4-7, 1978, Guam
3. Mycoplasma in Plants
   U.S.: Randolph E. McCoy, University of Florida
   R.O.C.: Hong-Ji Su, National Taiwan University
   Planning Session: September 3-6, 1977, Taipei and Tainan
   Seminar Dates: March 27-31, 1978, Taipei and Tainan

Advisory Meetings

Advisory meetings are sponsored for the development of proposals in a specific area to be designated by the implementing agencies (NSF and NSC) with the emphasis on a large scale interdisciplinary cooperative research project or projects. During the period under review, an advisory meeting on Earthquake Engineering and Landslides was held, August 29 through September 2, 1977, in Taipei, with 14 American and 38 Chinese scientists participating. The report of the Advisory Meeting is enclosed as an appendix.

In the period under review, recommendations from the 1976 advisory meeting on agricultural productivity began to emerge as proposals under the bilateral Program. One U.S. scientist, Dr. Janis Antonovics of Duke University, arrived in Taiwan in August 1977 for one year's collaborative research with Dr. Hong-Pang Wu of Academia Sinica on the genotype-environment interactions in the yield of the second crop of rice in Taiwan. Cooperative research proposals between scientists of Washington State University and Academia Sinica on the effects of environmental factors on phytotoxin production and nitrogen availability during the decomposition of rice residues in the soil are under review by NSC and NSF.

SUMMARY OF PROGRAM ACTIVITIES

The following table summarizes the activities of the Program for the period under review.

October 1, 1976 - September 30, 1977

	U.S.	R.O.C.
Short-term visiting scientists	14	1
Long-term visiting scientists	6	4
Cooperative research projects	34	34
Seminars:		
Held in	2	1
Attendees	40	86
Advisory Meeting:		
Held in	0	1
Attendees	14	38

Approximate total funds expended	US Funds US$1,334,437.00 ROC Funds US$775,558.00

Advisory Meeting
on
Earthquake Engineering and Landslide
Taipei, Republic of China
August 29 - September 2, 1977

Sponsoring Agencies
National Science Council
And
National Science Foundation

Under
The U.S.-R.O.C. Cooperative Science Program

PREFACE

At the annual meeting between representatives of the National Science Council (NSC) and the National Science Foundation (NSF) held in Taipei during the period October 26-28, 1976, earthquake engineering and landslide were selected as subject areas for the next joint venture to be conducted under the United States - Republic of China Cooperative Science Program. It was then decided that a small team of U.S. scientists under NSF sponsorship would visit Taiwan during 1977 for an advisory meeting with ROC counterparts to define the scope of this venture and to recommend priorities in the cooperative efforts to be implemented during fiscal year 1978.

Planning for the advisory meeting proceeded with Sheg-Taur Mau and Zen Yang serving as co-coordinators on the ROC side and Joseph Penzien serving as coordinator on the U.S. side. The meeting was held during the period August 29 - September 2, 1977, in Taipei.

The detailed program of the meeting, the names of participants, and the recommended cooperative research projects are included in this report.

On behalf of all participants, we as co-coordinators of the advisory meeting take this opportunity to express our sincere hope that this report will mark the beginning of a long and successful cooperative program of research between the U.S. and the R.O.C. on the subjects of earthquake engineering and landslide. We extend our thanks and appreciation to NSC and NSF, the sponsoring agencies.

(s) ____________
Joseph Penzien

(s) ____________
Sheng-Tau Mau

(s) ____________
Zen Yang

Advisory Meeting
On
Earthquake Engineering and Landslide
US-ROC Cooperative Science Program
August 29 - September 2, 1977
Taipei, Republic of China

PROGRAM

August 29, Monday

0830 - 0900	Opening Ceremony (Room 122)
0830	Opening remark by Dr. Shien-Siu Shu, Chairman of National Science Council.
0845	Introducing of participants.
	PLENARY SESSION -Presentation of state of arts papers (Room 124)
	Co-Chairmen: Joseph Penzien Sheng-Taur Mau
0900 - 0940	*STRONG SEISMIC MOTIONS MOTIONS*
0900	Paul C. Jennings Strong Earthquake Ground Motion.
0920	Yi-Ben Tsai Recent Research on Characteristics of Strong Motion and Seismic Risk in Taiwan.
0940 - 1020	*LIQUEFACTION*
0940	H. Bolton Seed and Kenneth L. Lee Empirical Procedures for Evaluating Liquefaction Potential During Earthquakes.
1000	Zen Yang Some Viewpoints of a Practicing Engineer on the Current Analysis Approach of Liquefaction.
1010	Chin-Der Ou Current Practice of Liquefaction Analysis in Taiwan.
1020 - 1040	Intermission.

1040 - 1120	*TESTING OF REINFORCED CONCRETE BUILDING ELEMENTS*
1040	Chi-Tung Yeh Testing of Reinforced Concrete Building Elements.
1100	Neil M. Hawkins and L--wu Lu Testing of Reinforced Concrete Building Elements.
1120 - 1200	*ROCKSLIDES*
1120	Ju-Jiang Hong General Report on Rockslides in Taiwan.
1140	Alfred J. Hendron Assessing the Dynamic Stability of Rock Slopes.
1200 - 1330	Lunch Break.
1330-1510	*GROUP DISCUSSIONS*
	GROUP A: Landslides, and Rockslides Co-Chairmen: Alfred J. Hendron Za-Chieh Moh
	GROUP B: Liquefaction, and Response of Dams Co-Chairmen: Kenneth L. Lee Zen Yang
	GROUP C: Testing of Reinforced Concrete Building Elements, and Soil-Structure Interaction Co-Chairmen: Le-wu Lu Chi-Tung Yeh
	GROUP D: Strong Seismic Motions Co-Chairmen: Paul C. Jennings Yi-Ben Tsai
1510 - 1530	Intermission.
1530 - 1700	*GROUP DISCUSSIONS* - Continue
1800 - 1930	Reception hosted by Dr. Shien-Siu Shu, Chairman of National Science Council.
August 30, Tuesday	
	PLENARY SESSION * Presentation of state-of-the-Arts papers (Room 124)
	Co-Chairmen: Joseph Penzien Zen Yang
0900 - 0940	*LANDSLIDES*

0900	Za-Chieh Moh Landslides in Taiwan: Some Case Reports.
0920	Wai-Fah Chen Mechanics of Slope Failures and Landslides.
0930	Hsia-Yang Fang Landslide Problems in Tropical Earthquake Regions.
0940 - 1040	*RESPONSE OF DAMS*
0940	Ray W. Clough and H. Bolton Seed Earthquake Resistant Design of Dams.
1000	Roger Y. Cheng Considerations for Seismic Design of Several High Dams in Taiwan.
1020	Yung-Yin Pai Earthquake Motion Observations of Tachien Arch Dam.
1040 - 1100	Intermission.
1100 - 1140	*SOIL-STRUCTURE INTERACTION*
1100	Anil K. Chopra and Joseph Penzien Earthquake Analysis of Structure Including Structure-Soil Interaction.
1100	Chau-Shioung Yeh Current Research on Soil-Structure Interaction.
1140 - 1220	*SOIL-STRUCTURE INTERACTION*
1140	Yi-Ben Tsai Present Status of Earthquake Prediction Research in Taiwan.
1200	Jack F. Evernden The U.S. Program in Earthquake Prediction.
1220 - 1400	Lunch Break.
1400 - 1520	*GROUP DISCUSSIONS* - Continued.
1520 - 1540	Intermission.
1540 - 1700	*GROUP DISCUSSIONS* - Continued
August 31, Wednesday	(Participants will divide into groups to visit research facilities related to earthquake engineering and landslide.)

September 1, Thursday

	PLENARY SESSION - Progress report by each group. (Room 124)
	Co-Chairmen: Sheng-Taur Mau Joseph Penzien
0900 - 1000	General Discussion.
1000 - 1020	Intermission.
1020 - 1200	General Dicsussion.
1200 - 1400	Lunch Break.
1400 - 1520	*GROUP DISCUSSIONS* - Drafting of Recommendations.
1520 - 1540	Intermission.
1540 - 1700	*GROUP DISCUSSIONS*- Drafting of Recommendations.

September 1, Friday

	PLENARY SESSION - Adopting of Recommendations. (Room 1243)
	Co-Chairmen: Zen Yang Joseph Penzien
0900 - 1020	General Discussions. Presentation of recommendations by Group A and Group B. Discussions follow each presentation.
1020 - 1040	Intermission.
1040 - 1200	General Discussions. Presentation of recommendations by Group C and Group D. Discussions follow each presentation.
1200 - 1330	Lunch Break.
1330 - 1630	Final Report by Drafting Committee.
1630 - 1700	Closing Ceremony.
1900 - 2100	Dinner Party hosted by Dr. Shien-Siu Shu, Chairman of National Science Council.

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Recommended Cooperative Research Projects

A. Landslides and Rockslides

Title No. 1:

Case Studies of Major Landslides.

Basic Purpose:

To evaluate the reliability of the present procedures for analyzing slope stability problems by comparing them with actual major slides.

Reason for Choice of Topic:

Case studies of major landslides provide the opportunity to apply the current state of the art (selecting shear strength values, pore pressures, and critical failure surfaces as dictated by the geology) of evaluation of slope stability in locations that have either failed or have experienced significant movement. These case studies enable engineers and geologists to evaluate the reliability of procedures and methodologies and to improve them as needed.

Recommended Research:

One possible landslide of particular interest is the Tsaoling Rockslide which had a volume of about 300 million cubic meters and was initially triggered by an earthquake in 1941. The volume of this slide is of the same order of magnitude as the Vajont Slide of 1963 in Italy. Such a project should be carried out by a multidisciplinary team including people working in the areas of airphoto interpretation, field geology, hydrogeology, geotechnical engineering, geodetic engineering and geophysics.

Distribution of Efforts:

The proposed project can be carried out with good balance of effort between U.S. and R.O.C. participants. The initial data, including field information, can be gathered by the R.O.C. participants with further work and analysis to be carried out jointly.

Title No. 2:

Landslide Zoning.

Basic Purpose:

To develop techniques and methodologies for landslide zoning.

Reason for Choice of Topic:

Studies needed to be made in a systematic way of those areas of Taiwan that experience a high frequency of landslide occurrences. In these areas, the geology and geotechnical environments need to be studied so that the basic causes of instability can be identified. This information will be helpful in site selection for development work. If the areas with potential landslides cannot be avoided, knowledge of the cause of instability will aid in the selection of remedial measures.

Recommended Research:

Techniques and methodologies for landslide zoning need to be developed. Areas with frequent landslide occurrences or potential occurrences can be selected in Taiwan to serve as models for the study.

Distribution of Efforts:

The proposed project can be carried out with good balance of effort between U.S. and R.O.C. participants. The development of techniques and methodologies can be carried out by such a joint effort. Their later application to Taiwan will be primarily the responsibility of R.O.C. investigators.

Title No. 3:

Shear Strength of Discontinuous Rock.

Basic Purpose:

To investigate both the residual angle of shearing resistance for typical rocks and to measure in the field the roughness along discontinuities.

Reason for Choice of Topic:

Many slope failures in R.O.C. and U.S. occur along bedding planes, joints, foliation or cleavage planes, and faults. Thus it is important to investigate the shear strength of these discontinuities. The manner in which the total strength is proportioned between the residual strength and the roughness along the discontinuities is very important in determining the behavior under earthquake conditions.

Recommended Research:

1. Build up the experimental capability in a rock and soil mechanics laboratory for investigating the residual angle of shearing resistance for a range of rock types in Taiwan.
2. Field measurement of the roughness along discontinuities of some typical rock formations in Taiwan.
3. Sampling of hard unweathered rocks for investigating their residual strength and of wall materials of discontinuous planes for determining the degree of alteration.
4. Analyses of failed rock slopes to test the theories of rock slope stability postulated by researchers.

Distribution of Efforts:

The proposed project can be carried out with good balance of effort between U.S. and R.O.C. participants. The development of theoretical and experimental technique can be carried out jointly. Field measurements can be performed by the R.O.C. participants.

Title No. 4:

Remote Sensing for Identifying Potential and Active Slide Areas.

Basic Purpose:

To use advanced technique in identifying landslide and potential slide areas.

Reason for Choice of Topic:

The Joint Commission for Rural Re-Construction and the Ministry of Interior of the R.O.C. government are sponsoring a national base-map compilation program. In this program aerial maps are used to compile orthophoto map. Remote sensing techniques such as infrared photograph and multiband photograph can greatly enhance the usefulness of conventional aerial photographs. These techniques can be used to assist in identifying landslides and potential slide areas. Maps prepared by using these techniques will be of great assistance in route selection, hillside development, etc.

Recommended Research:

To develop techniques, criteria, and methods of interpretation by using remote sensing in identifying landslides and potential slide areas.

Distribution of Efforts:

Remote sensing technique only recently has been imported to the R.O.C. In this respect, the U.S. is much more advanced. The U.S. participation in this project will play a dominate role with regard to the remote sensing technique itself; however, a balanced R.O.C. joint effort can be carried out in its application.

Title No. 5:

Methods of Slope Protection.

Basic Purpose:

To develop economical method(s) for slope protection or improving slope stability.

Reason for Choice of Topic:

Engineers and geologists determine from the present state of the art if certain slopes are either stable or unstable. If they are unstable, they may avoid the unstable area; but, if the unstable area cannot be avoided, then remedial measures must be implemented to protect the slope or to protect the structure from the slope.

Recommended Research:

Conventional slope protection usually consists of unloading the top of the slide, buttressing the bottom of the slide, draining the slope by means of horizontal drains, or employing new methods such as reinforced earth on smaller slopes. It is important carefully to consider any research proposal that would possibly yield a more economical method of improving slope stability.

Distribution of Efforts:

This project can be carried out with a balanced effort from both the U.S. and R.O.C. participants. Development of theoretical and experimental techniques can be carried out jointly.

B. LIQUEFACTION AND RESPONSE OF EARTH DAMS

Title No. 1:

Studies of Liquefaction Case Histories in Taiwan

Basic Purpose:

To expand the data base for the semi-empirical method of soil liquefaction recently developed and used extensively in the United States; to improve the empirical correlations when appropriate; and to determine whether or not the method is applicable to Taiwan.

Reason for Choice of Topic:

The currently used methods for evaluating the liquefaction potential of a given site rely heavily on empirical correlation between field and laboratory tests and observed performance of soils during past earthquakes. Although about 35 case history data points make up the basis for design procedures, only a few separate earthquakes are included and none of these are from Taiwan. In order to expand and improve this base, it is necessary to collect and analyze real case history data from additional sites. In order to verify that the method is applicable to Taiwan's condition of soils and earthquakes, it is essential that data from Taiwan be included.

Recommended Research:

Taiwan offers several excellent opportunities for studying the behavior of potentially liquefiable soils from past earthquakes. Some of these opportunities include:

(a) Wushantou (Coral Lake) dam: This is a 57m high hydraulic fill dam, completed in 1930, which has been shaken by several earthquakes during its lifetime. On at least one occasion the seismic shaking caused extensive damage. Studies of the soil properties and earthquake shaking that have occurred at this old dam in the past, correlated with the observed performance, will provide valuable data on the liquefaction potential of Taiwan soil. In addition, the studies will provide another valuable case history of the performance of earth dams to earthquake loading and may help to define the limits of shaking that this dam can safely withstand, which should be a valuable aid to future engineering studies directed toward the possible strengthening of this old but very important structure.

(b) Liquefaction in natural soils: Liquefaction, sand boils and ground failure have been recorded for several previous earthquakes, as for example: (1) Chiayi earthquake of 1941, M=7.1; (2) Hsin chu-Mialoi Earthquake of 1935, M=7.1; (3) Jui-Shui Earthquake of 1972, M=6.9; (4) possible earthquakes which may occur in future up to the end of the study period. It should be possible to revisit some of these earthquake areas, and by literature research, personal interviews, etc., locate sandy areas where liquefaction did or did not occur. Then at these particular study sites SPT tests could be performed and samples collected for laboratory cyclic loading tests. The data obtained should then be compared with those used to define the current method of analysis. In performing these liquefaction studies care should be taken to identify whether or not there are some anomalous soils such as ones of very angular sands, high shell content or other peculiar condition that may have low SPT values in the field but that may be relatively liquefaction resistant in laboratory cyclic tests, thus suggesting modifications to the current liquefaction analysis procedures.

Because earthquakes and the liquefaction phenomena occur in many places throughout the world where appropriate conditions occur, to the extent that the results of this research program improve the engineers ability to analyze accurately the liquefaction potential at a given site, they will be of value to all countries. For Taiwan, especially, the results should be of considerable value in assessing the soil stability at sites of development such as Taichung harbor, which is currently being constructed using hydraulic fill sand. It is noted that hydraulic filled sands placed without compaction traditionally have a reputation for being vulnerable to liquefaction during earthquakes.

Distribution of Efforts:

On a short range basis (2 years), the major effort should be concentrated on collecting and analyzing field data. This work would be largely carried out in Taiwan and would include literature searches of old earthquake accounts, field inspection trips to identify good sites for further study, drilling and soil sampling and assembling cyclic loading equipment. The American counterpart should visit Taiwan at about this time to review the results obtained and make detailed plans for the next stage which would be laboratory testing and analysis.

Cyclic triaxial tests should be carried out in Taiwan on some of the samples. In addition, some of the testing and analyses should also be done by a U.S. Counterpart. These U.S. studies should include standard cyclic triaxial tests to correlate with and supplement similar tests done in Taiwan; cyclic simple shear tests, which are a better simulation of field loading conditions than cyclic trixial tests, and various parameter studies to investigate effects of time after placement and small prior earthquakes, etc. Analytical calculations of ground response should be done in both countries.

The results of these short term studies hopefully will be to increase confidence in both countries in the methods used for soil liquefaction.

Longer range studies related to specific design projects should also be given early attention with effort increasing as time goes by, along with solicitation of cooperation of officials of the particular projects involved. Two such projects appear to be of considerable importance to the economy of Taiwan and also of potential importance for developing design procedures in any country: the hydraulic fill soils of the Taichung Harbor and the

Waushanto Dam. Should a liquefaction failure occur at either of these sites it would be a certain tragedy both in terms of money and lives lost. Similar sities also exist in the United States. Long range liquefaction research should be directed toward methods of assessing the potential dangers involved and improving the stability of these structures under earthquake loading.

To carry out long term studies of these subjects it would be advantageous to have several U.S. and R.O.C. researchers along with knowledgeable representatives of the project owners all working on related aspects coordinated through frequent project meetings.

Title No. 2:

Seismic Stability of Compacted Earth Dam

Basic Purpose:

To investigate appropriate methods for seismic stability analysis of compacted earthfill dams, with special emphasis on a case history study of the new Tsenqwen dam, which was shaken by a M=5.3 earthquake on April 14, 1976, at which time valuable response and performance data were recorded.

Reason for Choice of Topic:

Available evidence suggests that modern well constructed earthfill dams on a firm foundation will not fail by liquefaction and are not likely to develop large flow slides such as expected for loose natural sands and uncompacted hydraulic fills. The expected seismic effect on modern compacted fill dams involves some crust subsidence and possibly cracking. More research is needed to develop design procedures by which the amount of permanent seismic deformation may be estimated. An excellent opportunity to make such a comparison involves the new Tsengwen Dam. This 133m high compacted earthfill dam was shaken by a M=5.3 earthquake on April 14, 1976. Peak horizontal accelerations of 0.15g and 0.10g were recorded in the rock abutment. Piezometers within the dame recorded significant excess pore pressure and subsequent surveys indicated permanent crust settlements up to 4.4cm and horizontal movements up to 2.2cm in the upstream direction.

Recommended Research:

A seismic stability analysis of the Tsengwen Dam should be made for the actual shaking of the February 14, 1975 earthquake and the results compared with the observed performance. As a result, the current methods of analyses may need revision or modification. After the seismic stability analysis methods have been verified for this dam, they may then be used with more confidence in the analysis of other compacted earthfill dams in seismically active regions in any part of the world, including a reevaluation of existing earth dams for possible future earthquakes. One such case of particular interest to Taiwan would be a new dam currently under consideration for construction near Taipei. At this writing both a concrete and rockfill dams are being considered. If the results of the above mentioned research program lead to reliable methods for seismic stability analysis of earth dams, they should then be of valuable assistance to the design studies of this proposed new dam.

Distribution of Efforts:

The new Tsenqwen Dam was analyzed in 1975 by the US Bureau of Reclamation (UABR), for a maximum design earthquake of M=7.1 using recently developed methods. It would have been helpful had the dam been reanalyzed for the actual M=5.3 earthquake that occurred April 14, 1976 to demonstrate how well the analysis method can predict the actual observed performance. Portions of the soil test data obtained by the USBR would be appropriate for this reanalysis. A few additional tests should be performed to demonstrate the possible effect of aging on the cyclic strength.

Newly developed computer programs currently being developed in the USA should be used to estimate the permanent deformation. Further research is required in order to improve these computer techniques and to extend them for predicting excess pore pressures.

To verify that these theoretical analyses are in fact valid, it is essential that they be checked with observed performance on real structures. Thus, the Tsengwen Dam case history affords a very important opportunity for such comparison; thus, it would be expected to benefit U.S. researchers.

It is expected that the U.S. partner in a joint research program would take the lead in the initial computational phase; however, as developments permit, work could be done in Taiwan. On the other hand, the Taiwan researchers would obtain and verify the field performance data and the seismic ground motion records. With continuing effort in this area, the R.O.C. researchers would take the lead in performing various exploratory parametric studies to demonstrate the likely effect of various degrees of earthquake shaking on the performance of this dam.

The appropriate engineering agencies in Taiwan responsible for the design of dams should be kept informed of all progress and invited to participate where appropriate in the research studies. On a long-range basis, the seismic stability studies developed for the Tsenqwen Dam could then be used by researchers and personnel from R.O.C. institutions to analyze other existing or proposed compacted earth or rockfill dams with continued assistance from the U.S. researchers.

C. SEISMIC SAFETY OF A CONCRETE DAM

Title:

Earthquake Behavior of Techi Dam.

Basic Purpose:

To measure the earthquake response behavior of Techi Dam, and to compare its observed performance with mathematical predictions.

Reason for Choice of Topic:

Techi Dam is a typical thin shell arch dam built in a region with frequent earthquake activity. It has been extensively instrumented, with three strong-motion seismographs, three microseismographs, numerous strain meters, stress meters, etc. Four moderate earthquakes already have been recorded at Techi Dam since March 1975. Therefore it will provide an ideal structure for the purpose of verifying and improving earthquake response analysis procedures for concrete dams.

Recommended Research:

It is recommended that the following five phases be included:

1. Installation of Supplementary Strong-Motion Instruments
   Additional seismographs should be installed on the dam and in the surrounding rock structure to record the distribution of seismic input and more details of the structural response.

2. Analysis of the Dam's Vibration Properties.
   A detailed finite element model of the dam should be established, including appropriate portions of foundation and reservoir; then, the vibration mode shapes and frequencies should be calculated using a computer program.

3. Field Measurement of the Dam's Vibration Properties.
   Both (a) ambient and (b) vibration generator measurements of the vibration mode shapes, frequencies, and damping ratios should be made in the field at both low and full reservoir conditions and observed results compared with analytical predictions.

4. Refinement of the Mathematical Model.

   Numerical studies should be carried out in two basic areas, as follows, in order to develop modeling and analysis procedures.

   (a) Foundation Modeling—2D finite element analysis results should be compared with elastic half-plane results to verify the FEM model. These should then be extended to 3D and should be applied to the Techi Dam.
   (b) Reservoir Interaction—2K FEM results should be compared with continuum reservoir analyses, and the FEM procedures should then be extended to 3D for application to Techi Dam.

5. Shaking Table Feasibility Studies.

   Possible nonlinear (cracking) behavior of Techi Dam could probably be studied most effectively by model tests on a shaking table. However, before such experiments are performed, a model of suitable material should be developed to satisfy similitude requirements. Evaluation of the necessary material properties and development of the material should be carried out in this phase of the cooperative research project; however, the two phases should be funded separately.

Distribution of Efforts:

This project can be carried out with good balance of effort between U.S. and R.O.C. participants. The strong-motion instruments would be R.O.C. responsibility, as would the ambient virbration measurements. The vibration generator would be shipped from the U.S. for this test. Computer studies would be carried out in both countries.

D. EARTHQUAKE RESISTANCE OF REINFORCED CONCRETE BUILDING STRUCTURES

Title:

Earthquake Resistance of Reinforced Concrete Building Structures.

Basic Purpose:

(1) Development of mathematical models characterizing the stiffness of reinforced concrete buildings.
(2) Formulation of rational design and detailing criteria for reinforced concrete structural elements.

Reasons for Choice of Topic:

It is determined that the applicable architectural codes in the Republic of China and in the U.S. are very similar, especially those governing the design and construction of concrete buildings. Any research conducted on a cooperative basis will certainly benefit the engineering profession in both countries. Numerous opportunities exist for developing joint research projects in concrete structures subjected to high earthquake forces. Furthermore, several institutions in the R.O.C. now have plans significantly to expand their experimental facilities and assume active roles in structural research. It is therefore suggested that a comprehensive and well coordinated research program, including both experimental and analytical work, be developed and carefully executed within the framework of the U.S.-R.O.C. Cooperative Science Program.

Recommended Research:

As a result of the extensive discussions at the group meetings, the following research topics have been selected, and it is strongly recommended that active research in these topics be supported under the Cooperative Program with a view toward improving the earthquake resistant design practices in both countries:

1. *Material Properties Under High Levels of Cyclic Load*

   Numerous unsolved problems in this area exist, but the following are suggested as first-priority items: stress-strain relationships of concrete with different levels of confinement, bond-slip characteristics of deformed bars with and without end anchorage, and aggregate interlocking and energy absorption in shear.

2. *Strength and Ductility of Structural Components*

   Basic research is needed to develop a better understanding of: the relationship between flexure ductility and confinement in columns strength of beam-column joints subjected to uniaxial and biaxial bending and axial force, the influence of reinforcement arrangements (stirrup, tie, etc.) on ductility cyclic torsion of girders with and without slabs, and the diaphragm action of floor systems.

3. *Inelastic Behavior of Structural Frames*

   Extensive studies are necessary to examine the following: moment redistribution characteristics of frames (two and three dimensional) with and without gravity load, influence of reinforcement ratios of members on redistribution, effect of bond-slip and axial force on overall behavior, integral behavior of buildings including contributions of all structural elements, design requirements for infill panels and frame members, shear and flexural stiffness of frames with various arrangements (location, size, etc.) of infill panels.

4. *Ductile Structural Walls*

   First priority research should be on walls of intermediate height and should examine initially the following aspects: strength and ductility of walls with balanced shear and flexure effects, arrangement and distribution of reinforcement in walls, mathematical modeling for predicting cyclic load response, effect of openings on shear and flexure, applicability of coupled wall solutions to continuous frame-wall systems with openings.

5. Prefabricated and Post-Tensioned Systems

   At present, no major research activities on prefabricated and prestressed structures exist in the U.S. and R.O.C., although some preliminary work has been carried out in Canada, New Zealand, Japan, Romania, and Yugoslavia. Basic research is needed on partially prestressed members and frames, post-tensioned long-span floor systems, beam-to-column joints. Design guidelines for earthquake-resistant prestressed concrete structures are completely lacking and effort should be devoted to their development.

Distribution of Efforts:

It is strongly recommended that all future investigations be conducted with the final goal of developing design recommendations which eventually can be incorporated into building codes.

E. EARTHQUAKE RESPONSE OF STRUCTURES INCLUDING STRUCTURE-SOIL INTERACTION

Title No. 1:

Effects of Structure-Soil Interaction on Earthquake Response of Embedded Structures.

Basic Purpose:

To study the effects of structure-soil interaction on earthquake response of embedded structures.

Reason for Choice of Topic:

Much of the earlier research in dynamics of structure-soil interaction has been concerned with structures supported on the ground surface. More recently some investigations have been directed toward earthquake response of deeply embedded structures, such as nuclear power plants. However, comprehensive research investigations are necessary to develop a better understanding of this problem.

Recommended Research:

The recommended research may include the following topics:

1. Development of analytical procedures to determine dynamic stiffness (or impedance) coefficients for circular, strip and rectangular foundations embedded in a viscoelastic halfspace.
2. Definition of free-field earthquake ground motion along the structure-soil interface, including possible spatial variations based on various plausible hypotheses regarding the nature of earthquake ground motion.
3. Development of analytical procedures to determine the earthquake response of embedded structures including the effects of structure-soil interaction.
4. Parametric studies to evaluate the effects of structure-soil interaction on earthquake response of embedded structures, to identify the conditions under which these effects are significant, to identify the conditions under which such effects can be ignored. In these studies, the system properties and parameters should be chosen to be representative of buildings and nuclear power plant structures so that conclusions appropriate for each structural type can be reached.
5. Experimental verifications of analytical results.

Finally, studies aimed at reducing the results to a form suitable for use in design procedures for embedded structures are also needed.

Distribution of Efforts:

The recommended research can be effectively carried out on a cooperative basis as it easily can be divided into two complimentary projects. While each project could be carried out primarily in one country, the efforts of both projects should be fully coordinated to maximize the results of the overall program.

Title No. 2:

Effects of Structure-Soil Interaction on Inelastic Response of Structures to Earthquake Ground Motion.

Basic Purpose:

To study the effects of structure-soil interaction on inelastic response of structure to earthquake ground motion.

Reason for Choice of Topic:

Much of the earlier research in dynamics of structure-soil interaction has been based on the assumption of linearly elastic stiffness properties for the structure. However, several classes of structures, especially buildings, are usually designed on the basis that they would undergo significant inelastic deformations during intense earthquake motions. Research studies to investigate the effects of structure-soil interaction on earthquake response of structures designed on this basis are therefore recommended.

Recommended Research:

The studies may include the following topics:

1. Development of procedures for dynamic analysis of inelastic response of structures supported on viscoelastic soils.
2. Parametric studies to evaluate the effects of structure-soil interaction on inelastic response of structures, and to identify the differences between these results and those previously reported for elastic structural response.

3. Probabilistic studies to evaluate variances—which are known to be significant for nonlinear systems—of responses about their mean values.
4. Experimental verification of analytical results.

Finally, studies aimed at reducing the results to a form suitable for use in design procedures that recognize the ductility capacity of structures are also needed.

F. SEISMIC GROUND MOTIONS

Title No. 1:

Establishment of a Special Purpose Seismic Strong Ground Motion Array.

Basic Purpose:

To measure the dependence of potentially destructive ground motion on source mechanism, distance attenuation, site geology, depth of basement rock and topography.

Reason for Choice of Topic:

Many important questions remain concerning strong ground motion and its dependence on the way the energy is released at the source, the way the motion is affected by distance, the geologic features of the source region and local soil conditions and topography. While a large number of strong-motion instruments are located in the U.S., particularly in California, the probability of having very large earthquakes in California during the coming 5-10 years is very low. This makes it necessary that extensive strong-motion instrumentation be deployed in other parts of the world where seismicity is much higher.

Taiwan is among the most seismically active areas in the world. It has three hundred years of historical seismicity record, and about eighty years of instrumental record. Cumulative seismic data indicate that over several 100km x 100km areas in Taiwan, the recurrence rate of magnitude-6-earthquakes is on the order of every 3-5 years and of magnitude-7 about every 20 years. This high seismicity, coupled with the fact that no earthquake greater than 7 has occurred since the 1951 Hwailien event of magnitude 7.3, makes it highly desirable that a seismic strong-motion array be deployed in Taiwan to record future larger earthquakes. It is contemplated that a 20 to 60-element free-field strong-motion array, deployed in an area of diversified soil types, site geology, basement rock depth and surface topography, could almost double the current strong-motion data band should a large earthquake with its aftershock sequence occur in or near the array.

Recommended Research:

It is recommended that over a period of two to three years a suitable array of seismic strong-motion instruments be installed in one of the most seismically active and geologically diversified areas in Taiwan.

To maximize the usefulness of the recorded strong-motion data, an array site located at the northern portion of the East Longitudinal Valley, including the Hwalien international harbor, is recommended. The valley itself is formed by a giant transform fault, matching in size the San Andreas fault, but seismically several times more active. Along the floor of this valley flows the Shio-ku-luan river, into a complex system having its tributaries having deeply cut the valley into a complex system of topographic relief. At the same time, it develops extensive gravel beds and alluvial plains. Where it enters the ocean at the Hwalien harbor, it has deposited a large plain of diversified soil types, including bay mud.

It is believed that the recommended array offers a high potential for providing answers (or at least in improving our understanding) to the many important questions remaining concerning strong ground motion. Furthermore, low labor costs in ROC mitigate maintenance costs if such a project is to be carried out over a 5-10 year period. The long-term view of this research is apparent; it may be several years before significant records are obtained. The value of the data to be obtained, however, justifies the installation of the strong-motion instruments.

Distribution of Efforts:

It is envisioned that a joint U.S.-R.O.C. team of engineers and scientists would plan and inspect individual sites of the array and cooperate in the processing and interpretation of the strong-motion data. The installation and maintenance of the strong-motion instruments would be carried out by R.O.C. Engineers, and scientists from ROC would also have prime responsibility for processing the data, but U.S. research workers would cooperate by making available the use of state-of-the-art hardware (e.g. fast-scanning digitizers) and computer programs developed in the U.S.

Title No. 2:

Instrumentation of Selected Engineering Structures in R.O.C.

Basic Purpose:

To measure the earthquake response of major engineering structures of types that are common to both the U.S. and R.O.C.

Reason for Choice of Topic:

The high seismicity of the R.O.C. in comparison to that of the conterminous United States offers an excellent opportunity for united cooperation in the recording of the response of structures to strong earthquake motions. The type of structures considered would be those that are common to both the U.S. and the R.O.C. and could include earth and concrete dams, tunnels, harbor facilities, major bridges, etc. Building structures are not envisioned, unless they are of a type of construction common to both countries.

Recommended Research:

It is recommended that selected engineering structures in the R.O.C. be outfitted with strong-motion accelerographs to record earthquake response. Several potentially interesting structures exist for the recommended instrumentation program; three examples are discussed below:

1. The major tunnels of the Northern Railway—These tunnels, the largest of which is about 8km long, offer an excellent opportunity for measuring the earthquake response of this type of structure because they are in the most seismic area of R.O.C. An array consisting of four instruments along the tunnels, plus two or three free-field sites could be expected to record valuable information on the response of tunnels within a 10-year period.
2. The harbor facilities at Taichung—This harbor is in one of the more seismically active areas of R.O.C. There exist in this area opportunities to measure the response of piers and other major waterfront structures. In addition there is filled land in the habor area which can reasonably be expected to liquify in the event of strong earthquake shaking. A few instruments, suitably deployed, including some installations below the level of expected liquefaction, could provide field data on the onset and propagation of liquefaction which is not yet available to the engineering profession.
3. Modern concrete and earth dams—There are several major modern dams in the R.O.C. These include both earthfill dams and concrete arch dams. The response of these dams to earthquake motion is a topic of considerable interest in both countries. In the U.S., for example, the disastrous failure of the Teton Dam has focused attention on the Issue of the safety of dams. It is recommended that one or two dams located in the more seismic area of the R.O.C. be heavily instrumented with special arrays of strong-motion accelerographs in order to measure its earthquake motion.

Distribution of Efforts:

In order to maximize the benefits of projects of the type discussed above, it would be necessary to have significant participation from the research workers of each country on such matters as the selection of instrumentation, the design of the array and of individual installations, and in the determination of local geologic conditions and material properties of construction. In addition, the processing and interpretation of these data, and subsequent analysis of the data, would be a cooperative effort.

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